AMERICAN YEARBOOK OF INTERNATIONAL LAW
ISSN: 2732-9925
Vol.2, n.1, 2023 Article 3

Proliferation of small satellites and excessiveness in outer space

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DOI:10.5281/zenodo.10679914

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Abstract: The present investigation is based on the protection of outer space and of the excessive proliferation of the launches of small satellites that are able to have the sustainability of space activities. We give the definition of the term debris and of what is considered for the form of environmental pollution as a cross-border nature, a common resource that is necessary to deepen the relationship between international responsibility and environmental protection. The customary foundation of the no harm rule is organized by international, conventional and existing obligations regarding the protection of the spatial environment and the role of soft law. The principle of sustainable law is presented as a general principle of international law addressed on its role as an interpretative aid of the conventional obligations, i.e. the main theme of the protection of the space environment.

keywords: debris; spatial law; international responsibility; environmental protection; ICJ.

Introduction

When we talk about debris in extra atmospheric space we are talking about environmental problems and at the same time of cross-border pollution that affects a res communis as a resource that comes out of state jurisdiction and can be used by all states (Tronchetti, 2013; Von Der Dunk, 2015; Hobe, 2017; Brünner, Kömgsberger, Mayer, 2018; Dennerley, 2018; Cirkovic, 2022).

Thus, when we talk about debris we refer to:

"(...) waste products of human activities in space, including non-functioning satellites, fragments of space vehicles, but also particles generated during launch operations or as a result of collisions in orbit (…)".

Debris pollution has a global character that finds correspondence in the rules of international law, aimed at protecting the environment (Boyle, 1999; Evans, 2014; Cordonier Segger, Weeramantry, 2017). These are rules that perform a preventive function and are applicable in outer space according to Art. III of the treaty on space which obliges the relative respect of international law according to the United Nations Charter relating to space activities (Lefeber, 1006; Weishar, 2016). The topic of damage prevention in international law, as well as its own prevention is connected with the general rules of liability for environmental damage and the possible consequences. There is no shortage of norms and standards in international law that seek to prevent environmental damage

from non-compliance that entails state responsibility (Koivurova, 2013; Jensen, Watts, 2017; Townley, 2018; Chircop, 2018). International liability in this sector includes dangerous activities and also integrates liability given that the adoption of preventive precautions does not always avoid the occurrence of the related damage. To this day the advantages associated with small satellites and their diffusion seems to fulfill the related purpose of exploration and space utilization of mankind. The small size as well as the majority of these satellites are not representative of a risk that occurs at the time of re-entry and at the time it comes into contact with the atmosphere. They affect the level of pollution in space and of some privileged orbits. Already Art. I of the treaty on space claimed access, i.e. freedom of access which is not absolute but workable for the benefit of all states, such as an excessive increase in launches which represents multiple points of view[1], as a threat to sustainable law (Cinelli, Pogorzelska, 2013;

1Outer Space Treaty, Art. I.
https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties introouterspacetreaty.html

Martinez, 2019)[2] and for space activities[3].Certainly the continuous increase in frequency and the number of launches has as a consequence an increase in the debris that crowds the orbits and realizes the practice of a progressive appropriation of the environmental space by the major launchers to the detriment of future generations as well as the less technologically advanced states in the field. Thus it is requested that the rules governing the environmental protection of cosmic space be able to derive as a modus interpretandi a self-regulation obligation that begins with the states involved.

2The concept of sustainable development was coined by the Brundtland Commission in 1987 in the "Our Common Future" report which defines: "(...) sustainable development which: 'meets the needs of the present without compromising the ability of future generations to meet their own needs". In Preambular Text and Nine Guidelines, A/AC.105/C.1/2018/CRP., Conference room paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities, of 22 February 2018. Such an approach to the issue of interpretation was confirmed by the Human Rights Committee, Atasoy and Sarkut v. Turkey, Communication Nos 1853/2008 and 1854/2008, UN Doc CCPR/C/104/D/1854-1854/2008, 29 March 2012 [7.13] The Court decided: "(...) that most international human rights treaties are able to accommodate change through time due to their vaguely drafted text, affording considerable leeway to the interpreter. The interpreter cannot pursue a construal of the treaty that qualifies as a revision of the text (...)".

3Par. 2, which is affirmes that: "(...) the long-term sustainability of outer space activities is defined as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations. This is consistent with, and supports, the objectives of the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space and the Outer Space Treaty, as such objectives are integrally associated with a commitment to conducting space activities in a manner that addresses the basic need to ensure that the environment in outer space remains suitable for exploration and use by current and future generations (...)".

Space debris: Definitive technique

Speaking of debris production, it means the transfer of space objects outside the earth's atmosphere which, when their function ceases, are forced to remain in orbit around the earth. The draft convention on the subject prepared by the International Law Association in 1994 gave a more precise definition[4]. According to art.1(c):

"(...) debris is described as any inactive and useless object of human origin, if no change of these conditions can be considered reasonably probable in the future (...)" (Bockstiegel, 1995; Contant-Jorgenson, Làla, & Schrogl, 2006; De Man, 2016; Lyall, Larsen, 2017; Malinowska, 2017).

The departure of the mitigation tools (Ambrus, Rayfuse, Werner, 2017; Jakhu, Pelton, 2017; Froehlich, Seffinga, 2019)[5] reactivates the spatial object to restore the original function that does not distinguish objects that are no longer functional from fragments devoid of autonomous functionality. Establishing the cessation of functionality of any space object is difficult since

4Buenos Aires International Instrument on the Protection of the Environment from Damage Caused by Space Debris in ILA, Report of the Sixty-Sixth Conference, Buenos Aires, Argentina, 14-20 August 1994, p. 317.

5The Inter-Agency Space Debris Coordination Committee (IADC), for example, a body formed by the Space Agencies of thirteen countries: "(...) whose objectives include the study and identification of mitigation options, defines the debris as all made-man objects, including fragments and elements thereof, in Earth orbit or reentering the atmosphere, that are non-functional (...)". IADC Space Debris Mitigation Guidelines, Revision-September 2007. The COPUOS guidelines were also inspired by this definition, incorporated in the text of the resolution adopted by the General Assembly in December 2007. See: UNGA, A/RES/62/217, International cooperation in the peaceful uses of outer space of 22 December 2007. It should be noted: "(…) that the definition of debris contained therein, instead of being included in the text of the guidelines, appears in the "background" section. Its scope is expressly limited to the text of the document in question, and its non-binding character is highlighted, as well as the absence of reworking by the subcommittee on legal affairs (…)".

the object remains quiescent and activate it spontaneously after a certain period of time is questionable. It should be emphasized that the substantial distinction between functionality and operability as an active link is taken into account given that the satellite cannot be controlled from the ground and its absence does not affect the satellite's capacity for its own functionality. Detecting the absence of functionality does not imply that each value attributable to a satellite space object has a precise value of an intact satellite including its payload. It is possible to exclude that the object falls within the availability of its owner or of another person who continues to constitute a source of possible information to recover the data stored in the technology that is employed.

Origins of debris and its distribution

A debris does not have “a unique property” because it is not constitutive since two thirds of the relevant objects in space come from the related fragmentation phenomena and are dependent on collisions and explosions. Explosions occur due to fuel and batteries remaining on board after the object has ceased to function and this is the main cause of fragmentation. The debris from this type of event depends on the mass of the object and appears small when dealing with small satellites. Explosions involve launch vehicle stages that explode even months or years

after their launch day and are expected to increase the number of the related launches. Collisions are distinguished from unintentional and voluntary ones. The involuntaries contribute to the formation of a large debris cloud after the collision between the satellite Iridium and Cosmos 2251 (Von der Dunk, 2010). That is, a satellite of Russian nationality that hasn't worked since 2009 and has created about more than 2,000 traceable fragments. The frequency of this mouse is intended for the increase in density affecting the more crowded orbital zones. As for the voluntary collisions, they are created by the tests of anti-satellite weapons and have a close connection with the prohibition of space militarization but do not enter in the subject of this investigation.

The only natural mechanism for cleaning orbits depends on the effects of the Earth's atmosphere and on objects in orbit. The altitude effectiveness of the object is relative to the size of its frontal section (Alwes, Benko, & Schrogl, 1993). As for the altitude of the object it experiences intensely in the atmosphere when it is in friction with the atmosphere. Larger objects tend to be attracted to Earth's atmosphere by more compact objects of equal mass. This mechanism works and is found in the Low Earth Orbit (LEO)[6], i.e. the area where the objects are actually subjects that re-enter the atmosphere according to the order

6It is the area between 160 km and 2,000 km altitude.

months or years after launch.

Within this context, constellations are created that exploit economies of scale within the production of a large number of satellites that are identical in nature despite the increase in the density of the space population. The evolution of the space environment is based on mathematical models that depend on the basic assumptions where the LEO population is not stable even when the guidelines on the mitigation of each debris are applied[7]. In the case of a total cessation of launches, there is no substantial change. And for low orbit space is used for different types of activities with a large part of these benefiting from the use of LEO where the advantages are economic and technical. The altitude is lower and the amount of fuel is necessary for the relative launch and certainly lower due to the delay in the propagation of the signals. The low altitude results in the permitting of short orbital periods allowing the same region of the Earth to be photographed several times a day as a translation of the advantage for observation satellites. Of course, if this were the case, the risk of collisions increases according to the increase in density, where the orbits of use are also subject to greater risks. The simulations show that the risk zone is located at an altitude of 900 km (Wiedemann and others, 2011).

7 Inter-Agency Space Debris Coordination Committee, Stability of the Future Leo Environment, IADC-12-08, Rev. 1st January 2013, p. 17.

The collision at about 10km is increased according to the smallest fragments that pose a serious danger to space objects that are functional. As far as the dimensions of the debris are concerned, there is a certain variation in the damage that can be produced where collisions with fragments larger than 10 cm cause the relative total destruction of the space object, but the difference lies in the moment that the fragment is not traceable by the related Space Surveillance systems in use.

Environmental space density monitoring exists in systems known by Space Situational Awareness systems and are capable of locating objects and consequently cataloging them in orbit around the earth. The means used are variable according to the observation of the GEO and LEO orbit. Radar instruments and optical telescopes are used and due to knowledge of the position and trajectory of the debris they are essential to prevent any collisions that clash with the needs of national security and the instruments that are capable of objectively identifying this type of purpose. In the US the Joint Space Operation Center, managed by the Department of Defense which is responsible for the management of the Space Surveillance Network (SSN) has attempted to track approximately 17,800 objects over the years. Instead, as regards the Europe there are no similar systems but only single infrastructures that are dedicated to this purpose as in the case of the German Tracking and Imaging Radar (TIRA)

(Palkovitz, Masson-Zwaan, 2016; Larsen, 2017; Palkovitz, 2019; Krishnan Nair, 2019). Of course the information that arrived comes from the data provided by the American NHS. Its main objective is the provision of operators and the information necessary to effectively implement anti-collision measures. This type of analysis is carried out by government bodies since there is no similar obligation for private operators. As regards the associative activities such as for example the Space Data Association which is formed by the operators of geostationary satellites, they deal with the exchange of data which prohibits interference at the level of orbit and frequency. An equivalent body does not exist for the relevant operators at the level of orbit and frequency. An equivalent body does not exist for operators of small satellites. The creation helps to address the problems of lack of information and space activities conducted by non-traditional subjects easily escape from state control and increase the sensitivity of operators to international regulations where they often have their own knowledge.

Article IX of the Treaty on Space and the no harm rule

The protection of the space environment is based on art. IX, par. 2 of the space treaty which provides that the states in the exploration of extra-atmospheric space (Achilleas, 2014) including the moon and other celestial covers avoid the use of

appropriate measures with harmful effects of contamination and harmful modifications of the earth's medium which are due to the introduction of extraterrestrial substances (Gorove, 1872; Baker, 1989).

Art. IX includes the “harmful contamination”, i.e. a biological, chemical and nuclear pollution of space. This prediction is identified in the concerns of the scientific community of the possible repercussions on space experiments and activities in the same domain. The notion of harmful contamination has a search for ambiguity in relation to effectiveness (Lyall, 1999) and applicability to debris (Jasentuliyana, 1998; Ferreira, Snyman, 2013) given the generic nature of the terms that are used to push, favor the inclusive solution. Any introduction relating to the space of material that is able to bring undesirable effects in relation to the increased risk of collision is polluting (Stubbe, 2017). Spatial pollution is thus defined as:

“(…) a modification on the environment through human agency by the introduction on undesirable elements or by the undesirable use of elements (Diederiks-Verschoor, 1987) (...) of pollution provided by the UN Glossary of Environmental Statistics[8], which refers both (1) to the presence of substances, whose nature, position or quantity is capable of causing undesirable effects on the environment, and (2) to the production of polluting agents (…) each unwanted change of an environment with respect to the status quo ante, due to human intervention, constitutes contamination (…) the production of a certain level of debris is inherent in every spatial activity. Such a position, however, would constitute a violation of the art. I of the Treaty on Space, which guarantees the freedom of use of space and celestial

8UN Doc. ST/ESA/STAT/SER.F/67, Glossary of environmental statistics, United Nations, New York, 1997.

bodies (...) States are not obliged to avoid any contamination, but only that deemed harmful, an adjective that must be interpreted, in relation to the concept of due regard towards the interest of other states (…) anything that significantly affects the possibility of using space by other users is harmful (…) it is not a particular interest, limited to the members of the Space Treaty, but the interest general to the maintenance of freedom of access and exploitation, which make up the concept of space as a province of all mankind which makes the protection of the space environment an obligation whose respect is due towards the international community as a whole (...)" (Kopal, 1997).

It is impossible their use linked to the risk of collisions which consider as prohibited the introduction of material which excessively increases this risk. The hazard varies according to the overall state of the orbit where the event occurs and the fact remains that the abandonment of space objects are not controllable, increases the risk of collisions and it per se falls within the space of harmful contamination (Nevala, 2017)[9].

Art. IX is broken down into two different obligations where its nature must be assessed. First of all, the obligation to adopt measures to avoid contamination requires following a particular behavior and is classified with an obligation of conduct (Lefeber, 1996; Barboza, 2010; Weishaar, 2016). The duty to avoid any type of harmful contamination requires absolutely preventing the occurrence of an event that leads to a specific result. Also this obligation is of pure conduct that allows states to adopt measures that can be considered as compliant and

9Obviously, this consideration does not apply to non-maneuverable satellites for which the risk level is always the highest and therefore, in this respect, they do not differ from the debris.

disinterested in the effectiveness of the same. The non-violation of the ratio conceives a dual nature of obligation of conduct and of result at the same time (Wolfrum, 2011). The correspondence of the rule with customary law and the harm rule represents the transition from the conception of sovereignty as the ownership of absolute law in one's own territory (Hall, 2007). In speciem, the rule must be based:

> "(...) on the principle sic utere tuo ut alienum non laedas, which in turn draws force from two other fundamental principles of international law, namely the principle of sovereign equality between states and that of non-intervention in internal affairs (Halli, 2007) (…) sic utere tuo ut alienum non laedas, obliges states not to exercise their rights in a way harmful to other states, which includes a limit on the use of their territory, represented by the territorial integrity of the other states, an integrity that is violated in the event of environmental damage (…)".

The no harm rule therefore takes the form of the ban on using one's own territory in a way harmful to the territory of other states, affirmed for the first time in a famous arbitral ruling, and subsequently codified in Principle 21 of the Stockholm Declaration (Viñales, 2015)[10], as well as with identical formulation, in Principle 2 of the Rio Declaration, adopted by the United Nations Conference on the Environment and Development. Currently, the rule is generally held to be a customary law (Birnie, Boyle, 2009; Beyerlin, Stoutenburg,

10A/CONF.48/14/Rev.1, Principle 21: States have, in accordance with the Charter of the United Nations and the principles of international law, the right to exploit their own resources pursuant their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction.

2017), as confirmed by the International Court of Justice (ICJ) in the case relating to the Corfu canal (Di Stefano, Henry, 2012; Zimmermann, Tomuschat, Oellers-Frahm, Tams, Kashgar, Diehl, 2019) and, subsequently, in the opinion Legality of the Threat or Use of Nuclear Weapons (Brown Weiss, 1999; Bruke, 2011; Garvey, 2013; Caracciolo, Pedrazzi, Vassalli Di Dacchenhause, 2016; Ranganathan, 2017)[11], ruling in which the ICJ recognized the possibility that the damage extends to areas outside the national jurisdiction, without necessarily involving the territory or property of another state, thus shifting the focus of international protection from the territorial integrity of individual states to the global protection of the environment (Ranjeva, 1994; Fitzmaurice, 1996; Thouvein, 1997; Meadows, 1998; Liakopoulos, 2020)[12]. No harm rule also to areas outside

11See also from the ICJ: Legality of the Threat or Use by a State of Nuclear Weapons, Advisory Opinion, 8 July 1996, ICJ Reports 66, par. 29, which the court affirms that: "(...) The existence of the general obligation of states to ensure that activities within their jurisdiction and control respect the environment of other states or of areas beyond national control is now part of the corpus of international law relating to the environment (...) who objected that the reference to 'jurisdiction and control' rather than 'jurisdiction or control' limits extraterritorial application and that the Court's decision to refer to an obligation to respect the environment rather than not to cause harm can be seen as a weakening of the obligation imposed (...)".

12In case Gabcikovo-Nagymaros the ICJ affirms that: "(...) the great significance that it attaches to respect for the environment, not only for states but also for the whole mankind". Case concerning the Gabcikovo-Nagymaros Project, Hungary v. Slovakia, Judgment 25 September 1997, ICJ Reports 1997, p. 88, par. 53. The ICJ can also at any time on request of the instituted parties establishes a chamber for a specific business (art. 26, par. 2). In this case the components of the chamber: "(...) will be decided by ICJ with the consent of the parties. The possibility afforded to states in dispute to determine the composition of the ad hoc chambers, introduced with the 1978 amendment to ICJ Regulation, was undoubtedly the main factor behind the success of this type of former, which was used for the first time in the dispute between

territorial sovereignty it is perceived as a reflection of the interest they hold for the international community as a whole and is confirmed by the widespread nature of the consequences that can derive from different types of pollution. The no harm rule constitutes an obligation to due diligence, which corresponds to a duty to prevent the harmful consequences of the activities carried out by the state or its citizens (Sands, Peel, 2012).

The final objective of the rule is to avoid the occurrence of a harmful result in order to make it effective and the related content is indispensable as an obligation to adopt preventive measures for this purpose (Birnie, Boyle, 2009)[13]. Idea and affirmation based on the draft articles on the responsibility of states of 2001 which provides for the violation of an international obligation which requires a state to prevent a given event and is perfected when the relative event occurs (Liakopoulos, 2020)[14]. In order not to be useless, the rule must

United States and Canada on the delimitation of the maritime border in the region of Maine (Chamber constitution order, 20 January 1982, ICJ, Reports, 1992, par. 3ss). It was also used in the case of the border dispute, Burkina Faso v. Mali (ordinance for the constitution of the chamber of 3 April 1985, ICJ, Reports, 1985, par. 6ss), in the case of Elettronica Sicula SpA (ELSI) between United States and Italy (order for the constitution of the chamber of 2 March 1987, ICJ, Reports , 1987, par 3ss) and in the land, island and maritime border dispute, El Salvador v. Honduras (ordinance for the constitution of the chamber of 8 May 1987, in ICJ Reports, 1987, par. 19ss).

13See, Articles on Prevention of Transboundary Harm from Hazardous Activities. The Preamble, in fact, recalls the limited nature of state power in its territory, making explicit reference to Principle 2 of the Rio Declaration. See: UN. Doc A/56/10, Report of the International Law Commission, fiftythird session, 2001, par. 98.

14See: Art. 14, Draft Articles on Responsibility of States for Internationally

be reconstructed not as an obligation to achieve results but as a duty to maintain a certain behavior. In international law, the duty to protect the environment cannot be considered as an obligation of results in absolute terms but as a duty of conduct which establishes a standard of correctness.

Soft law and protection of the spatial environment

Up to now we have understood that both the art. IX and the no harm rule have not identified the relative measures where their adoption is necessary for the protection of the space environment. It is only a gap with apparent character. The formulation of the relevant standard in generic terms is compliant according to art. IX as a general limit to the freedom of use of space. This does not apply to individual measures to be effective and which cannot generically formulate the adoption of specific cases[15]. We also do not have an ad hoc international treaty for debris in our hands. There is only one set of resolutions of the General Assembly, i.e. declarations and other instruments such as guidelines or codes of conduct which are

Wrongful Acts, UN Doc. A/56/10, Report of the International Law Commission, fifty-third session, 23 April-1 June and 2 July-10 August 2001, par. 74.

15Draft Articles on Prevention of Transboundary Harm from Hazardous Activities all'Art. 3 general reference is made to the duty to adopt specific mitigation policies, as well as legislative and administrative rules with the aim of monitoring potentially harmful activity. Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, Un. Doc A/56/10, Report of the International Law Commission, fifty-third session, 2001, par. 98, sub.7.

found in the light of international forums and which enter the category of soft law. We have as a concrete element the instrument within which the content of obligations of a general nature are foreseen and integrated (Duupuy, 1990; Alam, Techera, 2013; Sidi Diallo, 2017)[16]. These are non-binding elements but of soft law with mandatory value that is recognized in the interaction with the relevant binding standards. Thus the states adhere in good faith and are committed by analogy according to art. 18 of the Vienna Convention on the Law of Treaties (VCLT) (Villiger, 2009; Fitzmaurice, Elias, Merkouris, 2010; Alland, 2012; Noute, 2013; Arato, 2013; Bjorge, 2014; Djeffal, 2016; Buga, 2018; Peat, 2019; Hollis, 2020; Fitzmaurice, Merkouris, 2020) and with the aim of not violating its object and purpose (Stubbe, 2017). This type of instruments show a uniform trend of the international community which takes into consideration the related requests for mitigation of the debris in the conduct of its space activities. National regulations are formulated to prevent through contracts directed and concluded by space agencies with third parties (Steinkogler, 2016).

The minimum appropriate threshold of the relative measures

16According to Dupuy: "(...) a "soft" norm can help to define the standards of good behavior corresponding to what is nowadays to be expected from a "well-governed state" without having been necessarily consecrated as an in-force customary norm (…)".

dedicated to the prevention of spatial contamination are not established by the states but by tools that see the intervention of competent bodies with appropriate knowledge. In particular in the Draft Articles on Prevention of Transboundary Harm from Hazardous Activities, the ILC established that:

"(...) the standard of due diligence against which the conduct of state of origin should be examined is that which is generally considered to be appropriate and proportional to the degree of risk of transboundary harm in the particular instance (...)" (Banda, 2019; Glicksman, Markell, Buzbee, 2019; Liakopoulos, 2020)[17].

For each activity there is a specific standard which is parameterized as the risk it is capable of causing. A standard characterized by a certain dynamism where the content of the environmental diligence obligations adopts standards and best practices, such as "standards that are subject to change according to technological progress in a given sector"[18]. A prevention that allows the adoption of protection standards at a more advanced level.

The mandatory nature of the Environmental Impact Assessment

The no harm rule as art. IX of the Treaty on Space, in addition

17Art.3, Draft Articles on Prevention of Transboundary Harm from Hazardous Activities.

18Which the court has affirmed that: "(...) it may change over time as measures considered sufficiently diligent at a certain moment may become not diligent enough in light, for instance, of new scientific or technological knowledge". Responsibilities and obligations of states sponsoring persons and entities with respect to activities in the Area, Advisory Opinion, ITLOS Case No 17, [2011] ITLOS Rep 10, par. 117.

to the inclusion of preventive measures and the related soft law instruments, also carries out an environmental impact assessment in a planning manner. The objective is to understand the risks of environmental damage that are connected to a preventive and planned activity based on information that has to do with the competent national authorities for the adoption of preventive measures. The relative provision has been introduced in various treaties and agreements that have to do with environmental protection (Epiney, 2009; Bayerlin, Marauein, 2011; Crawford, 2019) but its mandatory nature is directed by the no harm rule and accepted according to the customary rules as we have also seen in the Pulp Mills on the River Uruguay case (Cote, 2011)[19] where it was stated that:

"(...) requirement under general international law to undertake an environmental impact assessment", leaving the methods of the same to the state, and combining this duty with that of constantly monitoring possible harmful effects that are produced during the conduct of an activity (…)" (Cote, 2011).

What are the limits to the freedom of exploration and use of space?

The roots on the peaceful use of space, the prohibition of contamination, and the principle of due regard (Goehring, 2020)

19Pulp Mills on the River Uruguay, Argentina v. Uruguay, Judgment 20 Aprile 2010, ICJ Reports 2010, p.14, par. 204.

are functions that limit the freedom of use and exploration as a general prohibition of appropriation which has been sanctioned by art. II of the Treaty on Space (Del Vecchio, Virzo, 2019), as well as other prohibitions and limits that are provided for by the Charter of the UN and are contained in art. III of the Treaty on Space (Stubbe, 2017). The goal is always the exploitation of outer space as well as the positioning of artificial satellites in orbit around the earth (Kisiel, 2021), as a circumstance that leads in tempis to the development of a presumption of legality related to the exploitation of orbits (De Man, 2016) which are considered as a natural resource in their own right. The freedom of access and exploitation according to art. I of the Space Treaty departs from the right of any state to place its space objects in the orbit it wishes[20].

In theory, art. IX presents a precise, concrete obligation which highlights that the freedom of action of each state takes into consideration the limit which corresponds to the rights of the

20Already in the memo presented at the opening of the International Geophysical Year in 1958, the then United Nations ad hoc Commission for peaceful uses of space recognized the generalized acceptance of a principle: "to the effect that, in principle, outer space is, on conditions of equality, freely available for exploration and use by all in accordance with existing or future international law agreements", never contested not even by States that remained extraneous to the Space Treaty. On 1 January 2017, the OST had 105 ratifications on 193 member states of the United Nations and 25 signatures which, while not binding in full compliance with the Treaty, the subjects who affixed them bind them not to act contrary to good faith by violating the object and the purpose of the Treaty itself. A/AC.105/C.2/2017/CRP.7, Status of international agreements relating to activities in outer space as at 1 January 2017.

others[21]. Within this context, states shall plan their activities according to the regions of space which lend themselves equally to the performance of space activities which all related space objects are used in the electromagnetic spectrum for communications and for essential control and telemetry. This type of characteristics in practice make the orbits a natural resource of a limited type which find its basis in art. 44 of the founding Convention of the International Telecommunication Union (ITU) which imposes on the participating states a rational and efficient exploitation of the orbits[22].

Art. IV sets the general limit also in the subject of debris which allows the subject of Active Debris Removal to be taken into consideration. It is a containment approach capable of fulfilling the relative conservation necessary for the space environment where collisions between objects in orbit are destined to cause an exponential increase in the debris present in the LEO, making it thus unusable for a long time.

Art. VIII of the Space Treaty also establishes the state of registration as a result of the relative, exclusive jurisdiction of

21Furthermore, Art. I must be read in conjunction with Art. II of the Space Treaty which, by providing for the prohibition of appropriation of any area of space and celestial bodies, in addition to reflecting their international regime, prohibits any form of appropriation of space and, in full, of its resources, which occurs through use, occupation or any other means.

22The use of frequencies and the electromagnetic spectrum to the minimum necessary for the commissioning of essential services. Art. 44, Constitution and Convention of the International Telecommunication, version adopted in 2014 by the Plenipotentiary Conference.

the space objects where their permanence in space have no effect on the property and do not cease due to inactivity of their objects[23]. In analogous conditions, the obligation for states not to interfere with the relative space objects of others is an obligation where its violation is considered as an infringement of territorial sovereignty (Lyall, Larsen, 2017).

According to the principle of due regard, the relative connotations when the satellite is no longer active and without the state having its own jurisdiction and control over it, have the possibility of its restoration.

Art. I is thus interpreted as recognition to states where the freedom of access to space is a measure that is aimed at any purpose of use and exploration (Forse, 2013). The permanence of objects that have no relative function in space constitutes an impediment to the performance of the activities of the other states and an open violation of the principle of due regard according to art. IX. The balancing takes into account the functions performed by space objects and the needs of the states involved. States' space objects are not functional and continuous for a given orbit by refusing, removing or giving one's consent which is removed by third parties. They prevent access to the orbit created by an abuse of the freedoms guaranteed by art. I

23This implies, among other things, that where a spatial object is found beyond the borders of the state of registration, it must be returned to it, Art. VIII par. 2, Outer Space Treaty.

and according to the indirect violation of the prohibition of appropriation (Cheng, 1997), as an abuse of law and as a basis of international responsibility. The illegitimate use concerns the portion of the extra atmospheric space and is revealed by the relative unrepeatability of its characteristics[24]. The disposal of satellites that are at the end of their life can be considered as a duty of the state responsible according to the space activity which has its roots in articles I, II, VI and IX of the Space Treaty. The state of registration cannot give its consent by arbitrarily preventing the removal of an inactive satellite (Buga, 2018)[25].

24"(...) the identification of protected areas. The guidelines of the Inter Agency Space Debris Mitigation Committee define these as the low orbit and the geostationary orbit. The first is called "spherical region that extends from the Earth's surface up to an altitude of 2,000 km". The second is defined as "a segment of the spherical shell extending plus and minus 200 km" from the geostationary altitude at 35,786 km and encompassing a latitude band between plus and minus 15 degrees from the equator (...)". IADC Guidelines, op. cit., p. 11. Article 11: Notification and Recording of Frequency Assignments, ITU Provisional Final Acts, World Radiocommunication Conference (WRC-12), Modified RR NO.819811.44.

25According to Buga: "(...) a different solution would be to regulate the transfer of jurisdiction to the inactive satellite in favor of another state, such as a private individual, or a specially constituted organization after its declared inactivity. This transfer may be necessary when the original state is unable to proceed autonomously with the elimination of the object. At this juncture, attention should be drawn to the considerations already made regarding the legitimacy of an agreement between States translating the duty of registration, in accordance with Art. 36 of the Vienna Convention. As has been said, in fact, there do not seem to exist any rules in international law that would hinder the transfer of an obligation to a third State as a result of an agreement between all states holding the original obligation and on condition that it is accepted in writing (...)".

Liability for violation of relevant regulations in the space environment

The basis of international responsibility calls for the objective and subjective element (Liakopoulos, 2020). The violation of an international obligation by a state and its relative behavior does not comply with the obligation considered (Liakopoulos, 2020)[26] according to Art. IX of the Treaty on Space. Such an article requires states to avoid the related contamination events where the harmful potential is assessed in the light of the principle of sustainable development. The standard integrates the due diligence obligations which provide for the relative application of high-level debris mitigation standards, the carrying out of environmental impact assessments, as well as the adoption of legislative and administrative measures to guarantee compliance by private individuals. Failure to comply with these obligations results in a certain discrepancy in the relative state behavior and in the content of the law, as well as in the existence of the offense according to the objective element. The first document that emerges elements of debris mitigation at an international level constitutes the lines that are drawn up at the Inter Agency Space Debris Mitigation Committee (IADC) of 2002.

26Artt. 2, 12, Draft Articles on Responsibility of States for Internationally Wrongful Acts, in, UN Doc. A/56/10, Report of the International Law Commission, fifty-third session, 23 April-1 June and 2 July-10 August 2001, par. 74. IADC Space Debris Mitigation Guidelines, Revision-September 2007.

The subjective element, i.e. the harmful conduct is connected with a spatial object identifying the responsible state which is necessary for the establishment of the link between the object which caused the damage to a specific state. Article VI, par. 1 of the Treaty on Space has identified the activities as an attribution criterion which also takes into consideration other criteria which, in connection with art. VII attributes the relative jurisdiction and control of the space object and the associated activity related to the state of registry. The state of nationality reviews and authorizes the space activity as the appropriate state and registers the object as the launching state. The provisions corresponding to jurisdiction bases operate independently and are valid for establishing control over space activity in a precise manner leading to the identification of multiple subjects who are responsible for the illicit conduct.

Related data from Space Surveillance and information withheld at the time of its registration aid in the identification of the state, as well as the jurisdiction over the satellite and related activity. The American surveillance system with regard to the objects observed are part of a catalog using an alphanumeric code which is known by the name COSPAR (Schmidt-Tedd, Tennen, 2017)[27] including the launch number and the object positioned

27The international designator of a spatial object is information included in the official publications of the Committee on Space Research (COSPAR), il COSPAR Information Bullettin, entitled: Space Research Today of 2005.

in orbit. Other related useful information is communicated to the Secretary General of the United Nations according to what is established in Art. IV par.1 lett. b) of the Registration Convention (Hobe, 2019)[28].

Identifying state responsibility as an object through the use of an alphanumeric code means that the multiple launches are in compliance with the COSPAR code and in the absence of other additional information it is not sufficient to trace the objects to a single source. This system is suitable for identifying debris as generated during normal launch operations, which works for debris born after fragmentation of an accidental nature and it is not reasonable to assume the presence of an alphanumeric code whenever there is the possibility of a fragment.

Space debris and their transposition into national space legislation: soft law instruments

Space agencies nationwide register debris and contain definitions and forecasts of a high technical and precise level. In particular in paragraph 5.3.2. entitled “Objects passing through the LEO Region” it is envisaged that all satellites which pass through the LEO, or are potentially able to interfere with the

28UNGA Res. 62/101, Recommendations on enhancing the practice of states and international intergovernmental organisations in registering space objects of 17 December 2007, par. 2 the recommended measures include harmonization of registration procedures and in particular communication.

activities taking place in it, must be deorbited or, where appropriate, moved to an orbit in which their period of stay does not exceed twenty-five years following the end of the operations. A forecast, known precisely as the "twenty-five year rule". It still represents the main directive applied by national legislation to counter the accumulation in orbit of no longer useful space objects. According to the IADC guidelines, the General Assembly with Resolution n. 62/217 of 22 December 2007[29] adopted: "(…) its own set of guidelines, developed within the technical subcommittee (…)". It focuses on the risk posed by debris to human activities in space, maintaining the classic distinction between damage to people and damage to property and consists of seven general guidelines, divided into: prevention of waste release during normal operations, including the prevention of fragmentation events; end of mission arrangements and anti-collision manoeuvres. Many technical aspects have been neglected to facilitate the achievement of the broadest consensus. By way of example, it is sufficient to point out that there is no mention of deorbiting[30], but more generally of removal and the twenty-five-year rule is not expressly taken

29UNGA Res. 62/217, International cooperation in the peaceful uses of outer space, 22 December 2007, par. 26.

30The term in question is defined by the guidelines as: "(...) intentional changing of orbit for re-entry of a spacecraft or orbital stage into the Earth's atmosphere to eliminate the hazard it poses to other spacecraft and orbital stages, by applying a retarding force, usually via a propulsion system (...)".

up, but reference is generally made to a reasonable and appropriate post-mission lifetime limit for spacecraft in the LEO region. As regards the relative formal force of the UNCOPUOS guidelines should be noted for the relative adoption through an omnibus resolution with a binding nature. The UNCOPUOS underlines:

"(...) the purely voluntary nature of their adoption[31] and the instrument expressly provides that each state and international organization "should voluntarily take measures (...) to ensure that these guidelines are implemented (Marboe, 2016)[32] (...) of reference is the European Code of Conduct for Space Debris Mitigation (...)" (Belvisio, 2007: Mejìa Kaiser, 2019; Zannoni, 2022)[33].

The Code is based on the prevention of in-orbit malfunctions that avoid the release of components and the occurrence of collisions, the removal and disposal of satellites from crowded orbits, as well as the limitation of objects that are released during ordinary operations. The measures it contains are designed to apply to the different phases of a project and, therefore, include prevention, mission management, and

31UN Doc. A/62/20, Report of the Committee on the Peaceful Uses of Outer Space, General Assembly Official Records, fiftieth session, 2007, par. 118.

32Uncopuos Mitigation Guidelines, 3. Application.

33ISO International Standard 24113: Space Systems-space debris mitigation Requirements, 2011. Marboe, I., Small satellites. Regulatory challenges and chances, op. cit., COPUOS (Committee on the Peaceful Uses of Outer Space). (2018, July 17). Guidelines for the Long-term Sustainability of Outer Space Activities[https://undocs.org/A/AC.105/C.1/L.366]. UN Doc. A/AC.105/C.1/L.366. New York, NY: UN. COPUOS (Committee on the Peaceful Uses of Outer Space). (2019a) .Status of International Agreements Relating to Activities in Outer Space as at 1 January 2019. UN Doc. A/AC.105/C.2/2019/CRP.3. April 1, 2019, New York, NY: UN. COPUOS (Committee on the Peaceful Uses of Outer Space). (2019b, June 19). Report of the Scientific and Technical Subcommittee on its fifty-sixth session—Long-term sustainability of outer space. UN Doc. A/AC.105/L.318/Add.6.

disposal. It provides for a technical annex, aimed at facilitating the preparation of procedures to monitor compliance with the envisaged standards and, lastly, it adopts a long-term planning for the mitigation of debris. It also applies to all missions planned in the geographical area of reference, regardless of their purpose or their final destination. If adherence to the code constitutes a contractual condition for collaborating with projects directed by the national space agencies, all private operators wishing to collaborate with them will be bound to comply with it. The last tool to refer to is the Space Debris Mitigation standard 24113 developed by the International Organization for Standardization (ISO) (Marboe, 2016)[34], an organization made up of national bodies, whose purpose is to develop standards on the basis of international partnerships consensus to support innovation. It operates on a slightly different level than the guidelines and has the main objective of transforming the forecasts of the guidelines into real satellite design requirements, thus facilitating the standardization of production processes at a national level (Marboe, 2016)[35].

34ISO is an independent non-governmental organization founded in 1947 and made up of national bodies from 162 member states. The standards are drawn up by committees of international experts from different backgrounds and require approval by 75% of the members. In particular, the 24113 standard. Space Systems-Space Debris Mitigation was first published in 2010 and revised in 2011.

35Introduction, ISO 24113.

The purpose of all of the above has as its objective the harmonization of compliant legislation at national level. Let us not forget the equally important Compendium of Space Debris Mitigation Standards, adopted by states and international organizations[36] organized by Canada, the Czech Republic and Germany with reference to the Agenda "General exchange of information and views on legal mechanisms relating to space debris mitigation measures, taking into account the work of the Scientific and Technical Subcommittee", makes it clear that most of the states, including for example Argentina, Chile, the Czech Republic, Mexico, Poland, Spain and Switzerland, although they have not yet adopted national legislation on the point, declare to have adhered to the UNCOPUOS guidelines and to promote the adoption of similar instruments for the mitigation of debris. Other countries have adopted predictions similar to those contained in the analyzed instruments, which have become part of the requirements set by national legislation for the authorization of space activities, namely France[37], the United Kingdom, and Austria. A third set of states, however,

36First presented at the 53rd session of the UNCOPUOS Legal Commission in April 2014.

37French legislation, for example p is consistent with the IADC Guidelines and the ISO 24113 standard. The Decree on Technical Regulation of 2011 expressly provides that satellites intended for the LEO must be designed to be deorbited and, where this is not possible, they must be produced in so that they are no longer present in this area twenty five years after the end of the mission. Typically, this is achieved once again through controlled re-entry.

which includes Australia, Germany and Japan, addresses the issue of debris by adhering to international instruments through specific policies implemented by national space agencies (Marboe, 2016).

The applicability of the guidelines to small satellites

From the discussion analyzed up to now we have understood that the related instruments investigated focus on some general aspects, namely: - collision avoidance up to the maximum possible by placing the relative satellite repositioning manoeuvres; - the preservation of the orbital belts which are protected through de-orbiting by directing the satellite towards an area where its presence is also used for other space activities; - the prevention of the generation of debris that has to do with damage; - the minimization of the relative risk of accidental explosions by removing the energy sources and depleting the fuel or batteries.

At an international level, we do not have a distinction of debris content between small and traditional satellites. In practice, the envisaged measures require some structural requirements where small satellites are equipped. The problematic nature of the areas has to do with the possibility of preventing collisions up to the maximum during the operational phase and the end of life

operations (EOL) (Marboe, 2016; Froehlich, 2018)[38]. The fact remains that small satellites can voluntarily change trajectory given that they are not equipped with some on-board propulsion systems. This element means that the obstacle of the EOL operations is the de-orbiting of the satellite for mission purposes and its positioning in an orbit for other space missions. Compliance with the rule which normally dates back to 25 years prevails in planning the launch at a relative altitude where the satellite deteriorates spontaneously and due to orbital decay and without the need for movement. The autonomous determination of the positioning orbit constitutes a relative exception for all satellites that are piggyback launched and where the principal launch client determines the relative launch coordinates (Liakopoulos, 2019)[39]. The permanence in orbit has a negative nature in relation to the danger of collisions and because it cancels the benefits deriving from the main applications of small satellites and linked to the own testing of new technologies for de-orbiting and for active debris removal. The disposal of small satellites also presents two other types of alternatives. A first type which has as a requirement the manufacture of a de-

38IADC SDM, Guidelines 10; COPUOS SDM Guidelines, Guideline 3.

39For example, Virgin Orbit's Launcher One is designed to put small satellites of up to 500 kg in orbit. LauncherOne does not start from the ground, but is transported to an altitude of about 35,000 feet by a Virgin 747-400 plane called Cosmic Girl. Virgin Orbit should launch the first fully electric microsatellite (less than 60 kg) developed by SITAEL in collaboration with ESA-ASI.

orbiting capability as a minimum for all launched satellites and a certain altitude, as well as another optional route which suggests the planning of missions reserved for small satellites aboard, i.e. special vehicles which are equipped of means to always return in control (Pelton, 2015). The Compendium of Space debris mitigation standards (Marboe, 2017)[40] does not allow us to have in our hands the relative legislation, even of a comparative nature for the technical specifications that have to do with small satellites.

Constellations and small satellites

The evolution of a space traffic and the expected or not risk of collisions are debatable topics by specialized operators (Lewis, Schwarz, George, Stokes, 2014; Bastida Virgili; Krag, 2015; Peterson, Jenkin, Sorge, McVey, 2016. Radtke, Stoll, Lewis, Bastida Virgili, 2018; Sheer, Li, 2019)[41]. Various studies try to investigate the stability of the space environment in relation to the different consequences in orbit of mini-satellites with a mass of less than 100kg (including micro-nanosatellites, femtosatellites and picosatellites), with those having to do with the relative launch of the constellation which is made up of a

40Compendium of Space Debris Mitigation Standards Adopted by States and International Organizations'.

41See the Small Satellite Report: Trends and market observations. IAC-16, A6,2,4,x34551. IAC-16, A6,7,8,x32389.

total number of 1080 components (Bastida Virgili, Krag, 2015). The increase of the relative maneuvers is necessary to avoid collisions during the operational phase of the constellation and to offer a long period of exploitation. The relative overall impact on the space environment is significant in the operational phase which reduces to zero the difference between the small satellites, dangerous in the operational phase up to their exhaustion, and the relative operational complex which notices the stability of the space environment of the constellations involving the greater number of the relative components for the occupation of the chosen orbit.

What is the risk to the sustainability of space activities?

The sustainability of space activities is associated with nanosatellites, picosatellites and cubesats (Marboe, 2018)[42] and their regulation appears in the focus of the working group related to the sustainability of space activities[43].

The relative risk takes into consideration three different factors that can be combined with each other, namely the absence of propulsive capacity, the launch in constellations composed of a

42Catapult, Small Satellite Market Intelligence Report, Q4 2017.

43Catapult, Small Satellite Market Intelligence Report, Q4 2017. See also the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee. See Terms of reference and methods of work of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee, Working paper submitted by the Chair of the Working Group, A/AC.105/L.277, June 2010, p.4, par. 13

large number of objects, and the difficulty of surveying by space surveillance systems (Lyall, Larsen, 2018)[44]. The Guidelines for the long-term sustainability of outer space activities[45], in the specific "Policy" section, told us about the relative link between small satellites and the proliferation of debris. The Guideline no. 8, stated:

"(...) given the technical and cost constraints often associated with small-satellite missions, particular attention to the activities of non-governmental and private sector entities may be warranted to ensure that their activities do not become a significant source of long-lived orbital debris in the future (...)"[46].

The forecasts that aimed at small satellites and their operators have emerged during the progressive consolidation of their own guidelines and through the supplementary proposals that come from the individual Member States. The proposal presented by the Russian Federation (Lyal, Larsen, 2018)[47] favored the relative accretion of nanosatellites and picosatellites due to their size and poor traceability (Lyall, Larsen, 2018)[48]. The adoption

44A/AC.105/C.1/2010/CRP.3, 8 February 2010, p. 4.

45A/AC.105/C.1/L.339, Proposal for a draft report and a preliminary set of draft guidelines of the Working Group on the Long-term Sustainability of Outer Space Activities, guideline n.8.

46In the same spirit see also: UNGA, The Future We Want, A/RES/66/288 of 11th September 2012.

47A/AC.105/C.1/2016/CRP.15, Reviewing opportunities for achieving the Vienna Consensus on Space Security encompassing several regulatory domains, 17 February 2016.

48Ibidem, pag. 17: "(...) States and international intergovernmental organizations should, considering challenges that untraceable objects pose from the standpoint of safety in outer space, be encouraged to give all due significance and regulatory attention to providing design solutions that would enable radar and optical monitoring means to detect and observe small-size space objects launched into different orbits (...)".

of innovative techniques facilitates the identification and promotion of policies aimed at (a) increasing the localization accuracy, such as the installation of GNSS systems on board; (b) increase observability by radar systems; (c) avoid as far as possible orbits in which the life cycle of the satellite excessively exceeds the duration of its mission; (d) ensure that the life cycle of the satellite is reduced as much as possible after the end of the mission, through methods that increase atmospheric friction. Furthermore, as regards the constellations, solutions were promoted aimed at (e) avoiding the positioning of those composed of a very large number of satellites in the most crowded orbits according to guideline n. 30, entitled Design and operation of space objects regardless of their physical and operational characteristics, and informally known as "the small satellite guideline (…)" (Lyall, Larsen, 2018)[49]. The text

49A/AC.105/C.1/2018/CRP.18/Rev.1, Guideline n. 30: "30.1 Design and operation of space objects regardless of their physical and operational characteristics:"States and international intergovernmental organizations are encouraged to promote design approaches that increase the trackability of space objects, including small size space objects, regardless of their physical and operational characteristics, including small-size space objects, and those that are difficult to track throughout their orbital lifetime, as well as facilitate the accurate and precise determination of their position in orbit. Such design solutions could include the use of appropriate on-board technology. 30.2 States and international intergovernmental organizations should encourage manufacturers and operators of space objects, regardless of their physical and operational characteristics, to design such objects to implement applicable international and national space debris mitigation standards and/or guidelines in order to limit the long-term presence of space objects in protected regions of outer space after the end of their mission. 30.3 States and international intergovernmental organizations are encouraged to share their experiences and information on the operation and end-of-life disposal of space objects in furtherance of the long-term sustainability of space activities. Due to the importance of small-size

approved by UNCOPUOS includes some points, where, for example, par. 1 encourages states and international organizations to promote the related design which increases the traceability of small satellites and their localization through the positioning of on-board systems. Par. 2 provides that states and international organizations "should encourage" industry and operators to design space objects that comply with international guidelines and standards for debris containment. Par. 3 urges states and international organizations to share their knowledge on EOL operations and reaffirms the substantial importance of small satellites for all space programs, in particular for those of developing countries, emphasizing how through the implementation of these indications it is possible to support such programs without losing sight of the substantial respect for the sustainability needs of space activities. In paragraph 2 it was given emphasis on the supervision exercised by states and international organizations on small satellites in orbit, through the adoption of specific rules and policies for the missions, with particular attention to the orbital regions where the object is

space objects to all space programmes, in particular, for developing countries and emerging spacefaring countries, the implementation of the present guideline supports the development of space programmes, including the launching and operation of small-sized space objects or any other space objects that are difficult to track, in a way that promotes the long- term sustainability of outer space activities (...)". See also in argument: A/AC.105/C.2/L.307, Drafrt structure of a "Space 2030" agenda and implementation plaw, 1-2 April 2019. A/AC/Journal/2020/No.11, of 14 February 2020.

located and to the duration of its permanence in orbit. Paragraph 3 placed the emphasis on the often cooperative nature of missions dedicated to small satellites, expressly providing that states and international organizations conclude agreements aimed at regulating all aspects of such cooperation, in such a way as to avoid legislative gaps in the management of programs.

What are the interpretative approaches regarding the sustainable protection of the space environment?

The World Commission on Environment and Development established the link between economic development and environmental degradation and defined sustainable that development which:

"(…) meets the needs of the present without compromising the ability of future generations to meet their own needs (...)" (Holden, Linnerud, Banister, 2014)[50].

Elements, facts and positions that are traced to the Stockholm conference of 1972 were highlighted for the first time[51] at the historic United Nations Conference on Environment and Development in 1992 (Liakopoulos, 2011; Tully, 2012; Abate,

50In 1983, a Commission was established under the direction of Gro Harlem Brundtland with the task of assisting the United Nations Secretary General in deepening the issues related to the relationship between the environment and development. The conclusions he came to can be found in the Report entitled: "Our common future" of the Brundtland Report of 1987.

51United Nations Conference on Human Environment, Stockholm, 5-16 June 1972.

2014; Banda, 2018; Asadnabizadeh, 2019)[52]. The concept of sustainability of space activities means the prohibition of contamination of the use of the orbits. A logical reasoning goes back to article I of the Space Treaty which preserves the integrity of the space environment as a necessary introduction for the freedom of use and access to it[53]. By now it is evident

52An example is Art. 2 of the UN Framework Convention on Climate Change, which entered into force on 21 March 1994, 1771 UNTS 107, which sets the objective of the treaty: "stabilization of greenhouse gas concentration in the atmosphere at a level (...) to enable economic development to proceed in a sustainable manner". Subsequent conferences were held in Johannesburg in 2002 and in Rio De Janeiro in 2012. Based on them, two non-binding documents were adopted, namely the "Johannesburg Declaration on Sustainable Development" and "The future we want". UN Doc.A/CONF.199/20, Report of the World Summit on Sustainable Development, 4 settembre 2002, and UNGA Res. 66/228, The Future We Want, 11 September 2012.

53In the Preambular Text and Nine Guidelines, Conference room paper by the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities, A/AC.105/C.1/2018/CRP., 22.02.2018, p. 2, the concept of sustainability in space activities is defined as: "(...) the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations (...) and supports, the objectives of the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space and the Outer Space Treaty, as such objectives are integrally associated with a commitment to conducting space activities in a manner that addresses the basic need to ensure that the environment in outer space remains suitable for exploration and use by current and future generations. States understand that maintaining exploration and use of outer space for peaceful purposes is a goal to be pursued in the interest of all humankind (...)". The U.N. Office of the High Commissioner for Human Rights (OHCHR) determined: "(...) there is an open "question" of "the extent to which international environmental law principles can inform the application of human rights instruments (...)". U.N. High Commissioner for Human Rights, Analytical Study on the Relationship Between Human Rights and the Environment, par. 70, U.N. Doc. A/HRC/19/34 (Dec. 16, 2011, noted that: "(...) the extraterritorial dimensions of the human rights and environment interface provide fertile ground for further inquiry, particularly in relation to transboundary and global environmental issues the linkage between human rights and the environment raises the question whether human rights law recognizes states' extraterritorial obligations (…) further guidance (…) to inform options for further development of the law," especially relating to the extraterritorial obligations of states in the area of

that future usability can only be guaranteed by avoiding the uncontrolled increase of objects in orbit and the consequent risk of chain collisions. It is clear that the danger of a specific activity must be evaluated on the basis of its contribution to phenomena of uncontrolled growth of the debris. The consequences of a single launch in terms of collision risk are difficult to establish. An intervention of the precautionary principle as a component of the concept of sustainability assumes a leading role in determining what type of standards and regulations states must adopt to prevent harmful contamination. Correct application of the precautionary principle means that the risks potentially associated with each activity, even if not ascertained, must be taken into consideration. This essentially means that for each activity the adoption of the strictest standards must be considered mandatory, since it is the only suitable to minimize the risks. Within this circle, Article IX has been seen as a self-regulatory obligation which is assumed by states according to the interests of the entire international community and also in its perspective for future generations.

environmental protection (...)".

Wreck Removals and the Nairobi Convention: Towards an Analogue Application

The active debris removal (ADR) has not been taken into consideration by the international instruments. An important element that deals with the relative debris containment measures that are related to the liability and the exercise of jurisdiction of space activities and need a dedicated tool for processing and removal the debris as specified according to the reference to the dispersion of waste at sea, the wrecks of ships after shipwreck, the abandonment and dispersion of cargo. It is a phenomenon that is in harmony with debris despite the fact that it cannot be confined to a precise area.

Already Art. 60 of the Montego Bay Convention provided a good starting point for discussion as it envisaged the debris with the exclusive economic zone and how it ensures the relative safety of navigation[54]. It is a very important source which was

54"(…) the Convention, in fact, provides that states undertake to limit all forms of pollution of the marine environment, whatever their source, by adopting individually or jointly the necessary measures to prevent, reduce and keep under control the pollution levels of the marine environment, so as not to cause pollution damage to other states and their environment, and that pollution possibly caused by accidents or activities carried out under their jurisdiction and control does not spread beyond the areas where they exercise sovereign rights in accordance with the Convention. This provision argues in favor of the existence of environmental damage in the proper sense in the law of the sea, regardless of the damage to things and persons, which may derive as a secondary consequence, laying the foundations for further conventions aimed at regulating specific aspects (…)": United Nations Convention for the Law of the Sea, 10 December 1982, entered into force on 16 November 1994 1833 UNTS 396, Art. 194.

also represented in the Nairobi Convention (Naiddo, 2015)[55] and adopted in 2007. It is related to the removal of wrecks dangerous to navigation and the marine environment and constitutes a source of standards, transposed and applied to the spatial environment. The Convention is concerned:

"(...) to give a definition of wreck, identifying it as any (a) ship sunken or beached; or (b) any part of a ship sunken or beached, including any object which is or has been aboard such vessel; or (c) any object lost overboard from a vessel which is beached, sunk or adrift at sea; or (d) a vessel which is nearly, or may reasonably be expected to be, to sink or run aground, if effective measures have not already been taken to assist the ship or any property in danger (…). The debris is nothing but a space wreck (...) it must be taken into account that a satellite, even if it is no longer functional, it can continue to have a value due to the data stored in it where recoverable, or due to the technology used (...) the status of wreck cannot be assumed, but must be expressly declared by the person who has control over the object (...)".

Article 5 of the Nairobi Convention establishes in the event of casualties resulting in a wreck, the flag state must require the master or manager of the ship to notify without delay to the state concerned. It will not be possible to identify a single state concerned in the sense envisaged by the Convention[56], but it will be appropriate to consider all the owners or operators of satellites belonging to states whose space activities take place in the area where the wreck is located as recipients interested in notification at the time of the event. Some of them will be directly threatened by the presence of the wreck in a specific

55Nairobi Convention on the Removal of Wrecks, 23 May 2007, entered into force on 14 April 2015, 46 ILM 694.

56Ibidem, Art. 1 par. 10 according to which the one in whose Convention area the wreck is located has been affected.

orbit and, therefore, hold qualified interests[57]. With regard to the dangerousness of the wreck, the Convention refers to any condition or threat which (a) represents a danger or impediment to navigation, or (b) can reasonably be expected to cause seriously harmful consequences to the marine environment or damage to the seacoast or related interests of one or more states. The materially identified criteria for establishing whether a wreck constitutes a danger, refer to its size, proximity to navigation routes, density and frequency of traffic in the area concerned, and the nature of the cargo transported, all criteria which they also lend themselves to being adapted to the case of debris.

The dangerousness of a wreck is functional to establish a deadline within which the flag state must be notified and the wreck must be removed by the owner. If this is not done, or if the registered owner cannot be contacted, the state concerned may remove the wreck by the most practical and expeditious means available, consistent with considerations of safety and protection of the marine environment. Furthermore, in cases where immediate action is required, the state concerned, after

57Ibidem, Art. 1 par. 6 indicates by way of example: a) coastal, port and estuary maritime activities, including fishing activities, which constitute an essential means of livelihood for the persons concerned; b) tourist attractions and other economic interests of the area concerned; c) the health of the coastal population and the well-being of the area concerned, including the conservation of biological resources and marine fauna; and d) offshore and subsea infrastructures.

having informed the state of registration of the ship and the registered owner, is authorized by the Convention to proceed with the removal autonomously at the expense of the registered owner. The measures taken by the state concerned for the removal must be proportional to the danger posed by the wreck and must not go beyond what is reasonably necessary for the removal, having to cease as soon as this is completed. Furthermore, it is expressly stipulated that they shall not unnecessarily interfere with the rights and interests of other states, including the state of registry of the ship, and of any natural or legal person concerned. A similar regime for space wrecks would allow for the private interests of owners or operators to be taken into account, allowing each state concerned to intervene in the absence of flag state consent in situations where the owner does not personally arrange, or cannot be identified, but the wreck still constitutes a danger to navigation. In the case of vessels owned by a state and managed by a company which is registered as manager in that state, the latter is considered to be the owner.

Art. 10 establishes that the registered owner is independently responsible for the costs of locating, signaling and removing the wreck, except in certain particular circumstances which he must prove. The hypotheses of exemption from liability provided for by the provision in question are: a) an act of war, hostilities,

civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible nature, b) an act or omission deliberately carried out by third parties with the intent to cause harm, c) negligence or other wrongful act of a government or other authority responsible for the maintenance of light signals or other aids to navigation in the performance of that function. It appears to be extensible to a liability for the location, signaling and removal of debris considered dangerous, obviously subject to any limitations on the owner's liability in accordance with the applicable national and international regime. Providing direct liability for ownership and management also in the case of satellites could be a turning point for inducing private individuals to comply with the rules on debris mitigation.

Article 12 of the Convention provides:

"(...) that the owner is required to take out an insurance or other financial guarantee, to cover his liability under the Convention, for an amount equal to the limits of liability established by the applicable national or international regime. The certificate attesting the insurance must be issued by the state of registry and the proof must be presented by the registered owner to the competent authority of the state concerned, in case of declaration of danger of the wreck (...) could be expected the stipulation of a mandatory insurance covering the satellite removal phase as part of the formalities necessary for the release of the launch authorisation, in order to share the overall costs of ADR operations (...)".

Governance and low orbit

Space is part of the global commons as environments that are

subject to the jurisdiction of a single state which is considered as Common Pool Resources (CPRs) (Weeden, Chow, 2012; Paladini, 2019)[58]. The difficulty of access, as the main difficulty in regulating the use of a CPR, avoids that the individual user acts in his own exclusive interest and tends to abuse his rights leading to the exhaustion of the resource (Rose, 2011; Babcock, 2019; Larsen, 2019)[59]. This consequence maintains the exploitation of a certain threshold which is actually below the considered sustainability. These considerations apply according to the management of the low orbit and to the elaboration of a valid strategy for the containment of the number of launches of small satellites. The attempt to elaborate a valid strategy appears to be analyzed as a characteristic of a current regulatory system.

The development of international guidelines through national legislation is expected. This type of method has some

58According to Weedeen, Chow: "(...) a "commons," or more precisely, a commonpool resource, is a resource environment or domain that is characterized by an open access problem, meaning it is difficult to effectively bar others from accessing and benefitting from that resource. A "CPR is sufficiently large that it is difficult, but not impossible, to define recognized users and exclude other users altogether." Furthermore, CPRs exhibit a "subtractability of use" characteristic. This means that if one actor is using a CPR, it takes away, or subtracts, from another's ability to also use that same resource (...)".

59See also: A/AC.105/C.1/104, 20th November 2012, p. 9: "(...) the regulation of space, the elaboration of a management system in which the regulatory norms and the sanctioning mechanisms that the Economic doctrine has cataloged the strategies of regulation of common resources in four sets seems indispensable (...) the first category implies the abandonment of any type of regulation. The second tends to privatize the resource, limiting access to a single type of user. The third aims to support the development of voluntary standards and rules of conduct. The fourth, however, corresponds to a method that exploits a market logic, through the provision of a tax exemption or a system of negotiable quotas (...)".

shortcomings since it is based on a voluntary approach. The guidelines are obsolete and in some cases are described in small satellites. Technological progress in the sector requires that the reference standards are able to adapt in the near future, taking the name of adaptive governance. The ongoing need to provide orbital cleaning through ADR is effective in spurring the development of new technologies in the area of ADR. On the one hand, the taxation system imposes the quantitative payment of emissions. On the other hand, the system of licenses for a certain quota of emissions is an element of a governance that aim at an overall pollution that establishes a maximum level of emissions that reaches the assumption that the polluter is aware of the level of pollution costs and that he bears any other regular agent. The capacity of the model to favor technological innovation is taken into consideration in order to raise the level of sustainability for those who implement the greatest chances of implementation. Users are oriented towards financing new technologies as efforts result in cost savings of an individual nature. These are mechanisms adopted on a voluntary basis by states which through an international treaty based on the financing of repayments also in the participation of subjects, developing countries where the costs of participation exceed the benefits of operating in a LEO.

Concluding remarks

Until now we have understood that small satellites are part of space objects which are applied, at least in principle, to a regulation defining traditional space activities which highlight the gaps, points of friction and flexibility of international standards (Liakopoulos, 2020). According to the opinion expressed by the International Tribunal for the Law of the Sea (Plakokefalos, 2012; Schofield, Lee, Kwon, 2013)[60] the conduct of private individuals must comply with international law and is part of the more general trend of placing private conduct directly to the state, whenever widespread interests belonging to the international community as a whole are threatened (Liakopoulos, 2020).

Thus, the need for a specific regulation was confronted where small satellites have led to changes in relation to the authorization of space activities.

The relative practice has shown that small satellites escape the authorization duty given that the individual legislative acts limit their scope of application to a specific activity, presenting a low degree of openness towards innovative applications where the versatile nature of small satellites is an authorization process of

60Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area, Advisory Opinion, Seabed Disputes Chamber of the International Tribunal for the Law of the Sea, Case N. 17, 1st February 2011, par. 108.

institutional subjects with different and uncertain tasks, making the system unsuitable for actors with obligations deriving from international law in their sector.

The main obstacle is the distinction from traditional satellites given that it is difficult for the legislator to identify for each sector a double regime which proceeds to a case by case of the authorization forecasts and based on the characteristics of the mission. The distinction oriented towards the basic choices of the legislator and to a general perspective remains between maneuverable and not satellites. In particular, in the American system, the increase in authorization has pushed the legislator towards the department of commerce as a single subject, responsible for the authorization of all space activities except for the aspects of launch authorization and the related assignment of frequencies.

The change favoring private operators reduces the factors of confusion and it is often difficult to interpret international obligations in a way that minimizes the limitations on private economic initiative without assuming that these obligations also affect private individuals. Thus we speak for a responsibility for assuring what belongs to art. VI of the Treaty on Space which was interpreted by ITLOS in 2011 and based on an excessive relaxation of the authorization constraints in the case of small satellites that escaped traditional legislation. Situations of this

type are not exhausted in the case of small satellites due to piggyback launches. Starting from the territory of a state other than the national one, the launching countries not endowed with legislation on space activities can take advantage of the coordination gaps, an element that actually weighs down the situation of the adoption by some states of a restrictive interpretation of the notion of "state procuring the launch" involving private activities. The unwillingness of states is remedied by the powers to regulate private activity and by the attempt to voluntarily evade obligations at the international level.

Small satellites are the cause of an excessive proliferation of launches for the environment and a source of uncontrolled increase in debris despite the general content of art. IX of the Space Treaty which sought to regulate the duty of states to take appropriate measures to avoid the harmful contamination of space. The same article has handed over the no harm rule set up as a due diligence obligation. The relative interpretation with the principle of sustainability implies that the norm has an open character with the existing standards in the sector. Debris mitigation as a standard is contained as an instrument within soft law but is inapplicable to small satellites for technical reasons.

Excessive occupation of orbits also confirms in tempis a form of exclusive use of harmful contamination of space, as a reason for the impossibility of applying the existing standards to lead the development of specific tools to alternative solutions to devote to small satellites. Perhaps it is a condition that issues the authorization of a minimum requirement which is related to the de-orbiting capability of satellites launched at a certain altitude where the possibility of a solution on the front authorizes a plan demonstrating the impact of the planned activity on the space environment, the burden of drafting the launcher and the launch customer with the knowledge that it can be controlled by the states. The self-limitation of launches remains more difficult on the basis of a balance between the purpose of the mission and the general interest.

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